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Spruce Budworm on
Passamaquoddy Indian
Tribal Lands, Maine

Biological Evaluation Report

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Prepared by: IMANTS MILLERS, DENNIS SOUTO and LEW MCCREERY; Entomologists,
Forest Pest Management, USDA Forest Service PO Box 640,
Durham, NH 03824

ABSTRACT

Forest Pest Management recommends aerial application of Bt at 12 BIU's per acre to protect spruce on 14,000 acres on the Indian Township and 8,500 acres of spruce and fir in the Lowelltown Area - a total of 22,500 acres - in 1984. The poor stand conditions and moderate to high spruce budworm populations will result in spruce mortality unless foliage is protected. Salvage of dead and dying balsam fir is recommended where feasible. Forest Pest Management also recommends that the Passamaquoddy Indian Forestry Department adopt a long range forest management plan that includes silvicultural options to reduce future budworm caused losses.

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INTRODUCTION

The spruce budworm is a serious pest of softwoods in the Northeast. Many outbreaks have been recorded during the last 300 years (Blais 1983). The present outbreak in Maine began in the early 1950's. The outbreak ebbed in the late 1960's but never totally subsided. Since then the outbreak has spread to cover nearly the whole susceptible forest type in Maine, New Hampshire and Vermont. The State of Maine has conducted suppression projects intermittently since 1954 but annual suppression has been necessary since 1972.

The Passamaquoddy Tribe owns about 75,000 acres of forest land, mostly softwoods susceptible to the spruce budworm. Tribal ownership is increasing as additional areas are purchased as a result of the Maine Indian Claims Settlement Act.

Parts of the forest now owned by the Passamaquoddy Tribe were sprayed with chemicals before 1980 to suppress the spruce budworm. Some of the areas have not received protection from the spruce budworm since 1980. About 2,000 acres were treated with Bt in 1982. The same area and an additional 38,000 acres were sprayed with Bt in 1983 to prevent serious defoliation. Forest Pest Management has assisted the Tribe by the evaluation of the spruce budworm situation and has provided technical assistance in the planning and conduct of suppression projects.

SPRUCE BUDWORM

Species and Distribution

The spruce budworm, Choristoneura fumiferana (Clem.), is in outbreak status in Maine. Passamaquoddy Tribal forest lands are located on the southern edge of the outbreak in Maine (Figure 1).

Biology and Damage

The biology of the spruce budworm in the U.S. is summarized by Kucera and Orr (1981). A thorough review of the overall spruce budworm problem is presented in a series of articles in the Forestry Chronicle (MacArthur, 1975) and in The Maine Forest Review (Field, 1980). Briefly, the spruce budworm has 1 generation per year. Its population trends are believed to be controlled by food supply (the forest), spring weather and moth migrations. The budworm eggs are laid in July and early August; larvae hatch and find overwintering sites under bark and under cone scales. The 2nd instar larvae overwinter and emerge from late March to early May. They first mine needles, and later enter and mine developing buds. When buds flare, larvae start feeding on new needles. As larvae grow and new foliage is consumed, they feed also on older needles. The loss of buds and foliage first reduces tree growth, but after several years can lead to death of the tree.

balsam fir, red and black spruce (and hybrids) and hemlock, with scatterings of white and red pine. Some of the stands have large spruce in the overstory with hardwoods below, thus actually representing an open grown spruce stand. These large trees make up more than one third of the total stand volume.

The Springfield area, about 29,000 acres, has a similar forest type, but the area has more rolling topography. It became part of the Tribal forest lands as a result of the Maine Indian Claims Settlement Act. Previously the area was owned by a private company.

The Lowelltown Area, about 29,000 acres, is located on the western border of Maine. The area is hilly with several peaks nearly 2500 ft. above the adjacent lowland. The forest is composed of balsam fir stands in the lowland flats, balsam fir and red spruce mixed stands on higher ground where the ground is dry and mixedwoods and hardwoods on the hillsides and hilltops.

PRESENT FOREST CONDITION

This section will describe the condition of the host trees and stands affected by spruce budworm damage.

Indian Township

Spruce budworm defoliation has continued in this area for about 10 years. The area was sprayed in the late 1970's but not sprayed again until 1983. Dead balsam fir is common throughout the Township. About one half of the hemlock has top-kill. The condition of spruce varies from poor to moderate. Most of the Township was sprayed with Bt in 1983, and the trees appear to have responded fairly well. In 1983, defoliation was about 20 percent of current foliage. However, many of the stands remain in such poor condition, that even moderate spruce budworm populations would cause serious tree mortality. Figure 2 shows the results of an aerial sketch map survey for tree damage conducted by George Saufley of this office in 1983 (Appendix I). The heavily damaged area in the northeast corner of the Township is predominantly balsam fir, and more than half of the trees are dead or dying. The moderately damaged areas have stands with dead balsam fir and top-killed hemlock. Most of the red spruce here is heavily damaged, but mortality is rare. The lightly damaged areas have noticeable mortality and top-kill, but most of the stands appeared mostly green from the aircraft. The following acreage estimates of damage are made from the map:

1. Heavy - 900 acres
2. Moderate - 6,500 acres
3. Light - 10,500 acres

Springfield Area

Host stands in the Springfield Area are in better condition than those in Indian Township. During an aerial survey, moderate damage was found, mostly in the southwest corner of the township (Figure 3). Moderately damaged stands, with tree mortality common and many trees with top-kill were observed on 2,100 acres. Most of the dead trees were balsam fir, but top-kill was also present on the hemlock. The damage on spruce is heavy but mortality is not common.

Figure 2. Spruce budworm damage on the Indian Township - 1983

Key: (///) moderate (●) heavy mortality

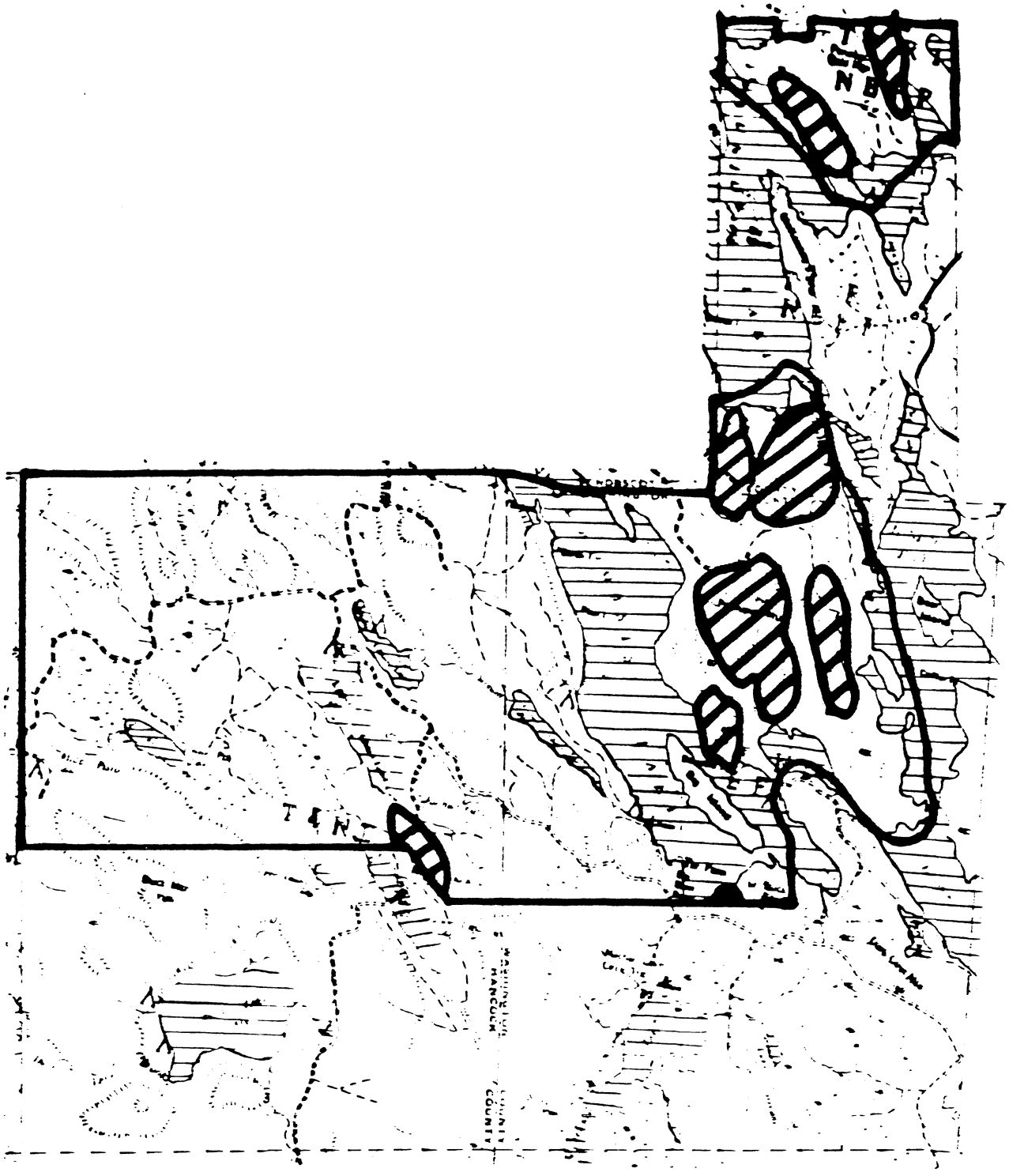

Figure 3. Spruce budworm damage in the Springfield Area - 1983

(///) moderate mortality

Most of the Springfield Area was sprayed with Bt in 1983 and the defoliation was less than 20 percent. The spruce foliage is being maintained and provided that further heavy defoliation does not occur, the condition of the stands should improve.

Lowelltown Area

Most of the balsam fir in the Lowelltown Area is either in poor condition or dead. Mortality of balsam fir is most prevalent in the lowland along waterways. The damage to red spruce is more variable. In the red spruce stands mixed with balsam fir, the red spruce is in fair to poor condition. In mixedwoods, the red spruce is in good condition.

A sketch map survey for damage was flown by George Saufley of this office. Later, A. Steele of the Passamaquoddy Forestry Department also sketch-mapped the damage at a lower altitude using a helicopter (Figure 4). Based on Steele's survey, the heavily damaged area covered about 4,700 acres; the moderately damaged area covered 8,500 acres; and the lightly damaged area covered about 800 acres. The damage classification used by Steele was as follows:

> Heavy damage (level I) - most of the balsam fir is dead and some spruce is dead; the live spruce is in poor to fair condition.
>
> Moderate damage (level II) - Some of the balsam fir is dead; the spruce is alive and in fair condition.
>
> Light damage (level III) - Some scattering of dead balsam fir; spruce condition appears good.

The area was recently acquired by the Tribe. Previously the area was protected for several years. Apparently, the continued heavy budworm activity combined with lack of protection during the ownership changeover period has resulted in extensive stand decline.

SPRUCE BUDWORM POPULATION TREND

The spruce budworm populations on the Indian Township and in the Springfield Area have decreased from the high and extremely high levels found in the fall of 1982, to moderate and low levels in 1983. In the Lowelltown Area, the spruce budworm populations are high in the severely damaged lowland flats. Since population survey data are lacking for 1982 and before, one may only speculate about the trend. Defoliation trends over the last 3 years indicate that budworm populations were high, declined in 1981 and 1982, and now may be on the rise again. The population survey methods used are presented in the Appendix II. The population conditions for the 3 areas are described below.

Indian Township

Most of the area was sprayed with Bt in 1983. Spruce budworm populations were greatly reduced and defoliation was less than 25 percent (Table 1). The southeastern corner and the northeastern corner have light populations and 1984 defoliation should be light to moderate. The remainder of the Township has moderate budworm population which may cause moderate to heavy defoliation.

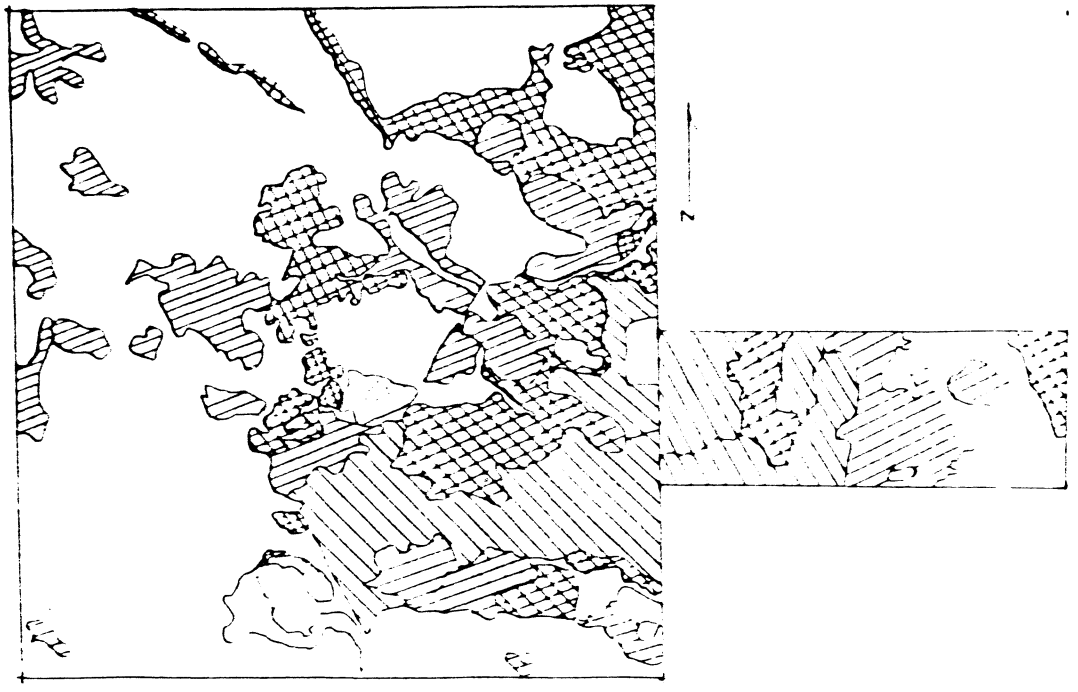

Figure 4. Spruce budworm damage in the Lowelltown Area, 1983

Table 1.--Spruce budworm populations and defoliation estimates on spruce on the Indian Township in 1983.

Plot No.	Budworm Population Post-spray Survey No. per 18" branch	Overwintering Survey No. per 36" branch	Spruce Defoliation Percent
1	0.3	---	16
2	0.3	---	26
3	0.2	---	16
4	0.1	---	16
5	-	359	25
6	-	482	34
7	-	381	15
8	-	226	8
9	-	270	21
10	-	227	13
11	-	45	14

Springfield Area

Spruce budworm populations in the Springfield Area appear to be moderate. The 1983 Bt treatments reduced budworm populations, based on the post-spray pupal survey, to 0.5 pupa or less per 18 inch branch (Table 2). In 3 locations, male moth, egg-mass and overwintering larval populations were measured (Table 3). These data also indicate moderate budworm populations.

Table 2.--Spruce budworm populations and defoliation estimates on spruce after the 1983 Bt treatment in the Springfield Area.

Spray Block	Budworms No./18" branch	Defoliation Percent
43	0.1	14
44	0.4	25
45	0.5	27
46	0.4	20
47	0.5	25
48	0.4	23
49	0.1	18
71	0.2	28
72	0.2	20
73	0.3	20

Table 3.--Spruce budworm populations on spruce in the Springfield Area pheromone plots in 1983.

Pheromone Plot	Spray Block	Post-Spray Pupae No./18" Branch	Moths No./trap	Egg-Mass No./36" branch	O.W. Larvae No./36" branch
Q1	71	0.2	36	91	209
Q3	73	0.3	7	47	208
Q4	71	0.2	31	68	365
Q5	72	0.2	8	50	209
Q6	72	0.2	18	27	88

DAMAGE PREDICTIONS FOR 1984 - ASSUMING PRESENT CONDITIONS CONTINUE WITHOUT INTERVENTION

Although severely damaged trees cannot recover completely in the year of treatment, the protection of the 1983 foliage in the Indian Township and the Springfield Area has reduced the immediate risk of greater tree mortality. The latter area was also treated in 1982, and the condition of the stands in twice-treated areas has improved. In the Lowelltown Area some severely damaged stands in the lowland flats have high budworm populations, and without protection can be expected to further deteriorate. On the higher ground in the Lowelltown Area, the budworm populations are low; the condition of spruce is fair, and some balsam fir mortality has occurred.

In the evaluation, the Spruce Budworm Damage Index developed for balsam fir (Appendix III) is used to predict damage on spruce. Since this Index has not been validated for spruce or hemlock, the reliability of the predictions are not certain. To rate the hazard, defoliation and budworm population data were collected from spruce, but the stand condition information, that is top-kill and tree vigor, had to be taken from balsam fir. Top kill is rare on spruce. Condition of spruce cannot readily be determined but fir condition is thought to be an indicator of spruce condition.

Some experts believe that the opportunity to protect spruce has passed once observable signs of poor spruce condition appear; that is the trees will not recover even if protected.

Hemlock damage predictions were not made. In the last 2 years, hemlock has had lower budworm populations than spruce and balsam fir (Table 4). Dead tops of hemlock from severe past damage are abundant in the Indian Township and the Springfield Area. It is apparent that hemlock is damaged by the budworm, but the damage process is not clear. The Spruce Budworm Damage Index cannot be used for hemlock because a portion of the 3rd year's needles are dropped.

Table 4.--Spruce budworm populations on hemlock in the Springfield Area in 1983 pheromone plots.

Plot No.	Egg-Mass No./36" branch	Overwintering Larvae No./36"branch
Q1	27	85
Q3	8	6
Q4	47	5
Q5	27	12
Q6	88	76

Lowelltown Area

The spruce budworm populations are highly variable in the Lowelltown Area (Table 5). The highest populations are found in lowland areas already heavily damaged by the budworm (Figure 7). Stands on higher ground at present do not have high budworm populations.

Table 5.--Spruce budworm populations and defoliation estimates on spruce in the Lowelltown Area in 1983.

Plot No.	Defoliation of Current Needles Percent	Overwintering Larvae No./36" Branch
1	27	1814
2	20	368
3	7	27
4	14	42
5	20	118
6	15	64
7	16	55
8	38	865
9	31	1329
10	10	18

The following hazard classes and index values are used in this biological evaluation.

Hazard Class	Rating Index Values	Expected Damage
Low	0 to 6	The stand is in no immediate danger of tree mortality or top-kill.
Moderate	7 to 15	Without treatment, the stand may deteriorate to high hazard condition in the next few years.
High	16 to 22	Without treatment, top-kill and tree mortality is expected.
Extreme	23 to 26	Most of the trees are dead and dying and are not likely to recover, even when additional defoliation does not occur.

Indian Township

Most of the sampled points in Indian Township were rated in high and near high hazard condition (Table 6 and Figure 5). About 900 acres in the northeast area is severely damaged and probably would not recover if treated. About 3,000 acres in the southwest and northeast corners have lighter budworm populations, less noticeable top-kill and moderate hazard ratings. Additional defoliation in 1984 may not cause tree mortality, but the tree condition may decline. The remaining 14,000 acres are in high and near high hazard condition. The additional defoliation expected in 1984 will return the trees to high hazard condition and tree mortality is expected to increase.

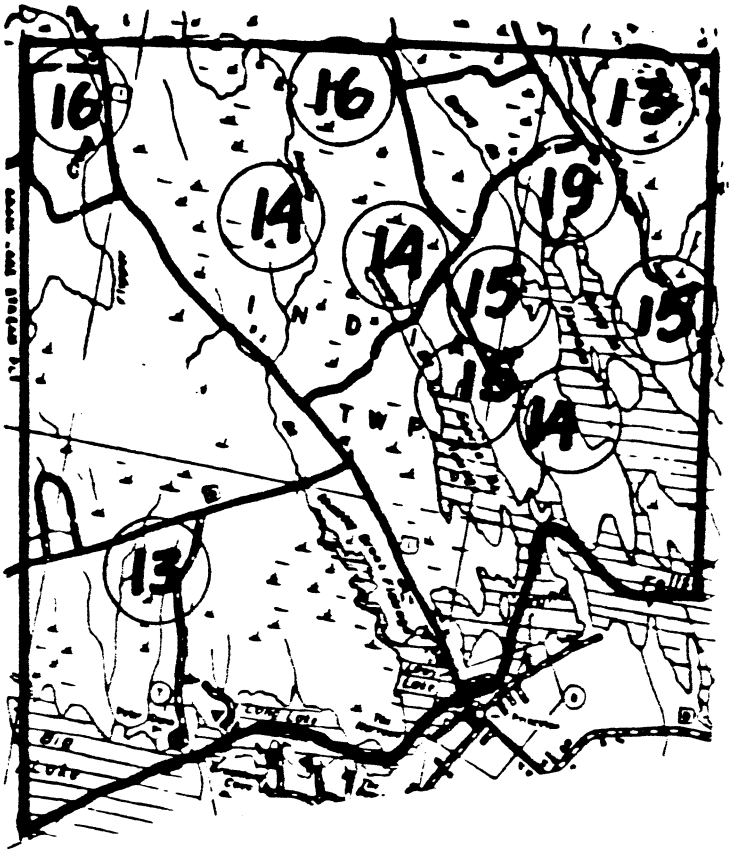

Figure 5. Spruce budworm hazard index for 1984 on the Indian Township (Above 15 is high; 7 to 15 is moderate)

Table 6.--Spruce damage prediction for 1984 on the Indian Township using the Spruce Budworm Hazard Index.

Plot No.	Defoliation '83	Defoliation '82 + '81	Top Kill	SBW Pop.	Tree Vigor	Hazard Index
1	1	6	3	2	1	13
2	2	6	3	2	2	15
3	1	6	3	2	2	14
4	1	6	3	2	2	14
5	2	6	3	2	3	16
6	2	6	3	2	3	16
7	1	6	3	2	3	15
8	1	6	3	2	3	14
9	2	9	3	2	3	19
10	1	6	3	2	3	15
11	1	6	3	1	2	13

Springfield Area

The forest conditions have improved as a result of the 1983 treatment, and most of the Area does not seem to be on the threshold of increased tree mortality like last year (Table 7 and Figure 6). Stand conditions are best in the eastern part that was sprayed with Bt in both 1982 and 1983.

Without treatment, the spruce budworm populations may build up and cause moderate defoliation in 1984. Should this occur the stands may return again to high hazard conditions. Moderate defoliation will result in continued slow growth but extensive tree mortality is not expected.

Table 7.--Spruce damage prediction for 1984 in the Springfield Area using the Spruce Budworm Hazard Index

Plot No.	Defoliation '83	Defoliation '82 + '81	Top Kill	SBW Pop.	Tree Vigor	Hazard Index
43	1	6	0	2	1	10
44	1	6	3	2	2	14
45	2	6	3	2	2	15
46	1	6	3	2	1	13
47	2	6	3	2	1	14
48	2	6	3	2	2	15
49	1	6	3	2	1	13
71	2	6	0	2	1	11
72	1	6	3	2	2	14
73	1	6	0	2	1	10

Lowelltown Area

The greatest damage expected in 1984 in the Lowelltown Area is in the areas where most of the balsam fir is already dead (Table 8 and Figure 8). Spruce in these areas is beginning to die. Without protection, mortality of spruce is expected to increase. On the higher ground, the condition of balsam fir is poor, while the spruce is in fair condition. Budworm populations are low in these upland stands and do not threaten spruce survival. Balsam fir condition, however, may further deteriorate.

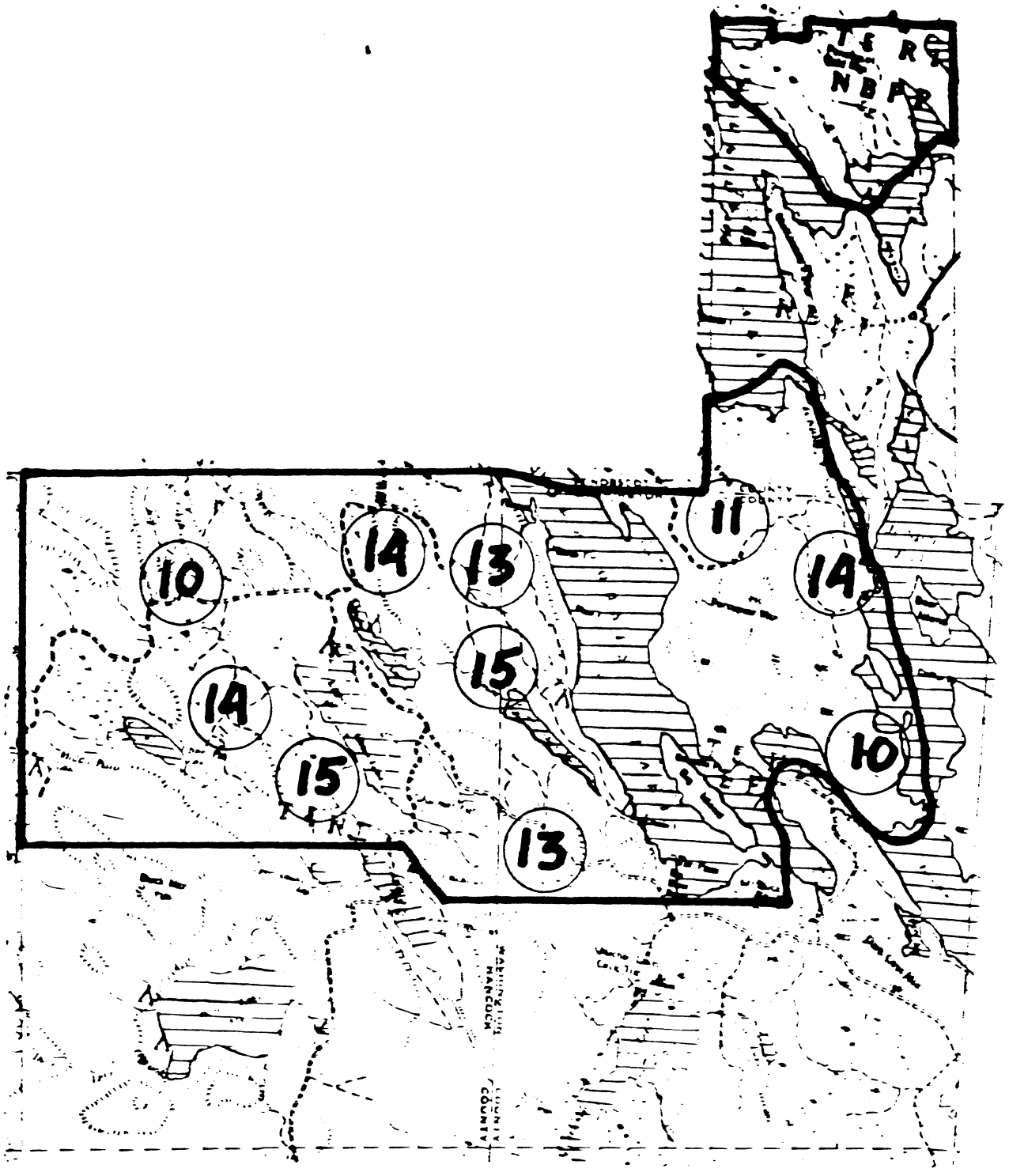

Figure 6. Spruce budworm hazard index for 1984 in the Springfield Area (Above 15 is high; 7 to 15 is moderate)

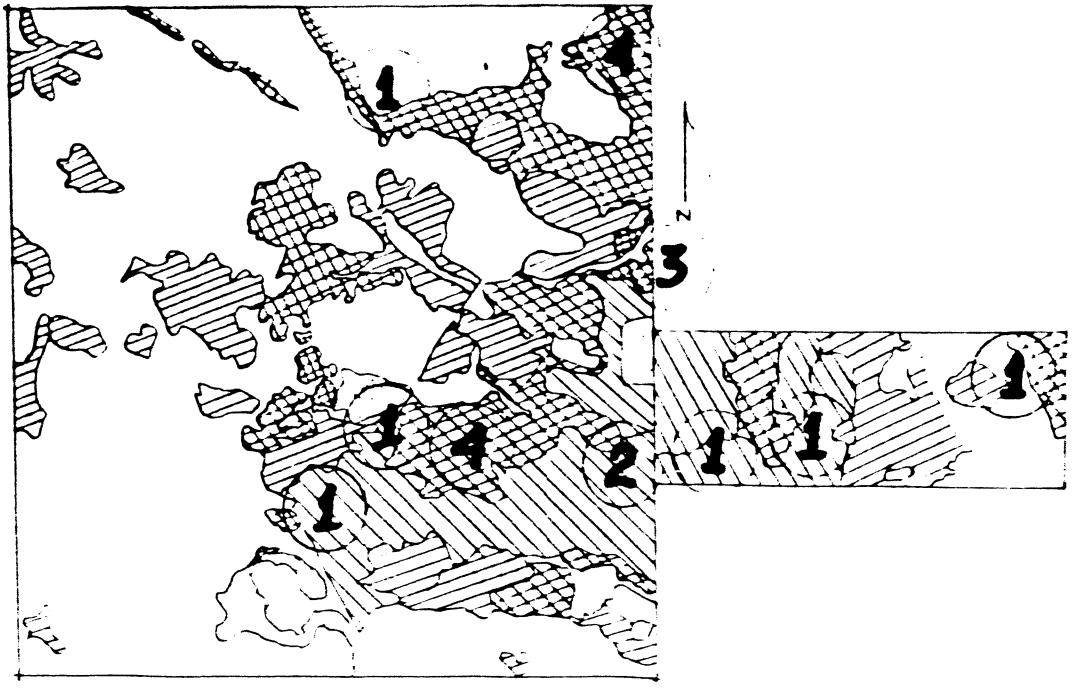

Figure 7.--Spruce budworm overwintering populations in the Lowelltown Area in the fall of 1983. (1-low; 2-moderate; 3-high; 4-very high).

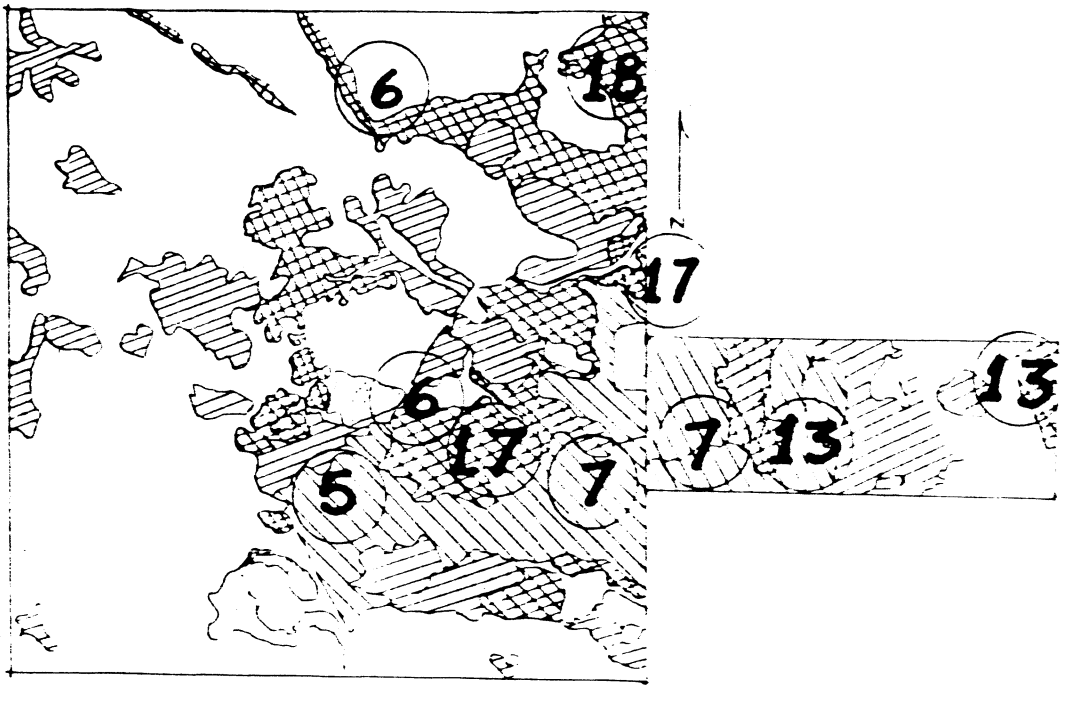

Figure 8.--Spruce budworm hazard index for 1984 in the Lowelltown Area. (Above 15 is high; 7 to 15 is moderate; less than 7 is low).

Table 8.--Spruce damage prediction for 1984 in the Lowelltown Area, using the Spruce Budworm Hazard Index

Plot No.	Defoliation '83	Defoliation '82 + '81	Top Kill	SBW Pop.	Tree Vigor	Hazard Index
1	2	6	3	4	2	17
2	1	3	0	2	1	7
3	1	3	0	1	0	5
4	1	3	0	1	1	6
5	1	3	0	1	2	7
6	1	6	3	1	2	13
7	1	6	3	1	2	13
8	2	6	3	3	3	17
9	2	6	3	4	3	18
10	1	3	0	1	1	6

SILVICULTURAL ALTERNATIVES TO REDUCE LOSSES FROM SPRUCE BUDWORM DAMAGE

The silvicultural alternatives presented are considered within the framework of management objectives of the Passamaquoddy Indian Forestry Department.

1. Utilization of merchantable timber to provide maximum income to the Tribe.

2. Maintain productivity of the forest for future income on a sustained basis.

3. Maintain the aesthetic qualities of the forest.

4. Maintain water quality of lakes and streams.

5. Maintain game habitat and protect nesting areas of the bald eagles and ospreys.

A. Long Range Silvicultural Options

The present forest on Tribal land was created by natural succession and past disturbances including spruce budworm outbreaks. Modifications in stand structure were brought about by cutting practices since the 1920's.

Spruce budworm has had a significant role in the management of susceptible softwood forests. The spruce budworm outbreak covers a large area and it is apparent that one landowner cannot influence the course of the outbreaks. These long term management options are presented in hopes of reducing future timber losses, both spruce and fir, rather than manipulating spruce budworm outbreaks.

1. Reduce rotation age to 50 years in balsam fir. This may require silvicultural treatments to increase growth and to protect the trees from defoliation during outbreak periods to sustain growth.

2. Maintain the low proportion of balsam fir found in many stands today. Where possible without excessive costs harvest merchantable balsam fir from mixed softwood and mixedwood stands to reduce the balsam fir porportion in favor of less vulnerable species. Protection from budworm may be necessary during outbreak periods.

3. Balance age class distribution of stands. Smaller proportion of area in mature and overmature stands now or in the future will decrease the severity of budworm damage and allow for more orderly harvest.

4. Increase diversity of tree species. In particular non-host softwood species should be encouraged, such as pines and black spruce.

B. Short Range Silvicultural Options

Because of past spruce budworm damage some stands are dead, others are in risk of dying within a year and the remainder have trees with moderate to poor vigor. Bt treatments in the Springfield Area and Indian Township over the past two years, have provided good foliage protection. However, some of the stands are in such poor condition that additional protection is needed if they are to survive budworm defoliation for the next several years. Actions on the Passamaquoddy lands will not change the course of the spruce budworm population trends in Maine. Nevertheless several options are available on a stand basis to reduce expenditures for protection and decrease losses from budworm damage:

1. Harvest merchantable wood threatened by the budworm in commercially operable stands.

   a. Salvage severely damaged stands where the wood is still acceptable. Usually, balsam fir stands can be harvested for about 5 years after mortality begins.

   b. Harvest mature and overmature stands where possible before tree mortality begins. Apply shelterwood cuts in stands where spruce is in good condition, regeneration is not present, and wind firmness is not a problem. Protection may be necessary until regeneration has established.

   c. Selectively remove balsam fir from softwood and mixedwood stands where commercially feasible to increase less vulnerable species component in the stand. However, foliage protection may be necessary for these residual trees.

2. Abandonment of harvesting and protection of spruce budworm vulnerable stands where commercial operations are not possible before wood deteriorates.

   a. Poor sites, low volumes, poor access and similar situations may prohibit harvesting of the present crop.

   b. Buffer zones around eagle and osprey nesting sites may be abandoned.

c. Scattered low volumes of balsam fir within softwood and mixedwood stands, may be allowed to die to reduce the vulnerability of the future stand.

3. Foliage protection with insecticides to prevent further deterioration of tree condition.

   a. Prevent excessive mortality of mature and overmature trees until harvest (storage on stump). The criteria for selecting stands for protection should be as follows:

      (1) Past budworm damage sufficiently severe so that another year of defoliation will dramatically increase tree mortality in the stand.

      (2) Stands are merchantable and operable and will be accessible by the time of scheduled harvest.

      (3) Stands cannot be harvested within next 5 years, or before the wood will deteriorate.

   b. Protect a sufficient proportion of the foliage to allow reasonable growth to maintain future supply of wood (growth protection). The criteria for these stands should be as follows:

      (1) More than 50 percent defoliation is predicted.

      (2) Good sites and adequate stocking to normally allow growth at the rate of 1 cord per acre.

      (3) Future potential for harvest.

      (4) Past damage will not preclude improvement in condition.

FOREST PEST MANAGEMENT RECOMMENDATIONS

A. Long Range

We suggest that the Passamaquoddy Indian Forestry Department consider all the long range management options discussed above. We also encourage development of a spruce budworm management plan as part of a forest management plan, which evaluates each softwood and mixedwood stand and prescribes future silvicultural methods to reduce spruce budworm damage and maximize wood production.

B. Short Range

INDIAN TOWNSHIP:

1. Apply Bt on 14,000 acres in the Township to protect spruce. The moderate level of spruce budworm population may cause heavy defoliation on the previously heavily damaged trees. The hazard index is high and just below high. The expected damage, without protection, is likely to result in tree mortality and deterioration in condition of the stand. The 3,000 acres in the southwest and northeast corners are not recommended for treatment because tree mortality is not expected.

2. Salvage the severely damaged area in the northeast corner of the Township - about 900 acres. The stands are predominantly balsam fir, and thus, clear-cutting will probably be necessary.

3. Abandon areas where harvesting and aerial spraying are not possible because of the likely disturbance to the nesting bald eagles and ospreys. These areas were not treated in 1983.

4. Presalvage all mature and overmature balsam fir, hemlock and spruce in operable stands. In mixed softwood stands where partial cuts are feasible, remove balsam fir in preference to spruce.

SPRINGFIELD AREA:

1. Salvage and presalvage all the balsam fir where logging is feasible; abandon balsam fir in stands that do not have operable volumes.

2. Aerial spraying is not recommended because the spruce budworm populations are low and the additional defoliation is not likely to cause tree mortality in 1984.

LOWELLTOWN AREA:

1. Apply Bt on 8,500 acres of heavily damaged stands to protect the spruce and balsam fir. Additional inventory is advised to remove stands where sufficient live operable volumes do not exist to justify spraying.

2. Salvage clear-cuts are recommended in the severely damaged stands, about 4,700 acres.

3. Consider presalvage of all mature and overmature balsam fir where operable volumes are present.

C. Pesticide Recommendation

Since Tribal policy is not to use chemical insecticides, only application of Bt is considered her. Apply Bt by aircraft at the rate of 12 BIU's per acre in concentrate (NEAT) application of 32 fl. oz. to 48 fl. oz. per acre. Fixed wing aircraft or helicopters may be used provided that the spraying systems can deliver small droplets, in the range of 50 to 100 micrometers in diameter. Application should be timed to early larval instars as soon as larvae switch from needlemining to mining and feeding on the spruce buds.

REFERENCES CITED

Blais, J. R. 1983. Trends in the frequency, extent, and severity of spruce budworm outbreaks in eastern Canada. Can. J. For. Res. 13:539-547.

Field, D. B. (Editor) 1980. The Maine Forest Review, Volume 13. Maine Chapter, Society of American Foresters. 52 pp.

Kucera, D. K. and P. W. Orr. 1981. Spruce budworm in the Eastern United States. Forest Insect and Disease Leaflet No. 160. USDA Forest Service. 8 pp.

MacArthur, J. D. (Editor) 1975. The Forestry Chronicle, Volume 51 Number 4: 135-160.

McCreery, L. R. 1983. Biological evaluation of spruce budworm on Passamaquoddy Trust lands in Maine, 1982. USDA Forest Service, Northeastern Area. Administrative Rpt. 23 pp.

Trial, H. Jr. and M. E. Devine. 1983. Spruce budworm in Maine: Results of the 1982 Project; biological conditions in 1982; and expected infestation conditions for 1983. Maine Forest Service, Department of Conservation, Tech. Rpt. 19: 76 pp.

APPENDIX I

AERIAL SKETCH-MAPPING SURVEY TO DELINEATE SPRUCE BUDWORM DAMAGED STANDS ON THE PASSAMAQUODDY TRIBAL LANDS.

The aerial sketch-mapping survey was done by George Saufley, Forest Pest Management, Durham Field Office, USDA Forest Service and Al Steele, Passamaquoddy Forestry Department. Flights were conducted on June 19, 1983 in a Cessna 180 at 1000 ft. above terrain. Although, the primary purpose was to map browning from 1983 spruce budworm defoliation, rain and wind the previous week had removed most of the loose needles. Thus, most of the mapping was based on overall stand appearance and abundance of dead tops and severely damaged or dead trees. The following stand damage classes were used in mapping.

1. None - Stands mostly green although thin crowns and occasional dead tree may be present.

2. Light - Grey tree tops common and tree mortality noticeable, but not more than 5 percent.

3. Moderate - Grey tree tops and grey whole trees abundant; at least 50 percent of trees still have shades of green.

4. Heavy - Most of the trees in the stand are grey; only few trees, less than 20 percent have green, or shades of green crown.

APPENDIX II

SPRUCE BUDWORM POPULATION SURVEYS - PUPAL, PHEROMONE TRAPS, EGG-MASS AND OVERWINTERING LARVAE

PUPAL SURVEY

Pupal survey was conducted in the areas sprayed with Bt during the 1983 Suppression Project. Samples were collected as part of the spray efficacy evaluation in the Indian Township and Springfield Area. Although, data is still being analyzed, the preliminary results are used in this Biological Evaluation. Each sample was the average number of pupae per 18" mid-crown branch collected from 20 spruce trees, at a rate of 2 branches per tree. The location and number of samples depended on the Bt treatment used in the area. In each area, 4 lines of 20 trees were sampled. In the tables, the average of the 4 lines is presented.

Spruce budworm population estimates at the time of pupation were collected as part of the post-spray evaluation of the 1983 Suppression project. Each spray block had 4 lines of 20 trees each. In a line, the trees were about 50 ft. apart. Two, 18 inch long branch was cut from the midcrown of each tree. The number of larvae, pupae and emerged pupal skins were counted and recorded. The average number of budworms per 18 inch branch for the spray block was used to determine population density. Current defoliation was estimated from 20 shoots per branch collected during pupal survey. For hazard rating purposes, the budworm population densities were estimated from the spray blocks closest to the sample points taken in 1982.

MOTH CATCHES WITH PHEROMONE TRAPS

Five plots (Labelled Q) had been established in the Springfield Area as part of a special project to evaluate the usefulness of pheromone traps to estimate spruce budworm populations and to predict damage (Work-plan, Durham F.O., 1982). In each of the plots, 5 traps were set out about 2 chains apart, one in a center and 1 in each cardinal compass direction. The traps were set out during the pupal survey and collected after moth flights had ended.

EGG-MASS SURVEY

Spruce budworm egg-mass populations were estimated only in the Springfield Area. In each of 5 plots, one, 36 inch long branch was cut from each of 10 dominant/ codominant spruces. The branches were labelled and brought to the Durham, NH laboratory for examination. These plots (Labelled Q) are part of the Pheromone Trap Evaluation Project and have been sampled 2 years. The samples were collected in the last week of August and searched in the laboratory during September.

Later, the same branches were soaked in sodium hydroxide solution to extract overwintering larvae.

OVERWINTERING LARVAL SURVEY

Overwintering larval (OW) population samples were collected from late August

(pheromone project plots) until end of October. Each plot consisted of 5-36 inch long branches taken at the rate of 1 each from 5 dominant/codominant spruces. The plots were scattered in the sample areas to provide an estimate of average conditions. At the same time stand condition data were recorded that later were used for Spruce Budworm Hazard Index. Branch measurements, length and maximum width was recorded to estimate the surface area of the foliated branch.

The standard extraction methods prescribed for overwintering second instar larvae were used in the Durham, NH laboratory under the supervision of Robin Despins (Dorais and Kettela, 1982). Special care was used in rinsing branches to remove larvae from the hiding places under bark. Less than 10 percent of larvae were missed with a single rinse method, as determined from spot checks with second and third rinse.

APPENDIX III

SPRUCE BUDWORM HAZARD INDEX - USING STAND CONDITION AND EXPECTED DAMAGE

The Spruce Budworm Hazard Index was developed by the Maritimes Forest Research Center, Canadian Forestry Service (Dorais and Kettela, 1983). Later the method was adopted in Maine and is used currently by the Maine Forest Service (Trial and Devine, 1983).

The spruce budworm hazard index is based on tree defoliation, current and previous two years, presence of top-kill in the stand, the vigor of the stand, and the present spruce budworm population as determined either from egg-mass surveys or overwintering larval surveys.

The Hazard Index was developed to predict damage on balsam fir and to plan suppression needs. Its usefulness to predict damage on spruce is not known, but it is the only method available. Spruce tends to have more foliage than balsam fir and thus more larvae may be needed per branch to defoliate it. At the same time, spruce seems to be more vulnerable to defoliation than balsam fir.

G. Mott, former research scientist with the USDA Forest Service, is of the opinion that spruce may be able to withstand 2 to 3 years longer defoliation, than balsam fir, but then succumb rapidly, even when some foliage is still present in the crown (Personal communications). Spruce does not usually display top-kill. Thus, for the index ratings, observations of tree vigor and top-kill are taken from balsam fir. Similar problems exist in applying the hazard rating to hemlock. The branches usually keep only 2 years of needles, and a partial third. Thus, past defoliation index values cannot be estimated for hemlock. Top-kill of hemlock does occur, however. Since, the hemlock damage has been less severe in the last two years, our evaluations have been based primarily for spruce.

HAZARD RATING OF SPRUCE BUDWORM DAMAGED STANDS

AREA:_____ STAND:_____ DATE:_____

HAZARD ITEM			HAZARD WEIGHT	INDEX VALUE
Current Defoliation (%)				
0 - 5			0	
6 - 20			1	
21 - 50			2	
51 - 80			4	
81 or more			6	_____
Combined Defoliation-Previous 2 Yrs (%)				
0 - 9			0	
10 - 49			3	
50 -129			6	
130 or more			9	_____
Top-kill Present			3	_____
SBW Population per 100 sq. ft.				
Egg-Mass	2nd Instar Larvae			
1 - 99	1 - 175		1	
100 - 239	176 - 500		2	
240 - 399	501 - 1100		3	
400 or more	1101 or more		4	_____
Tree Vigor in Stands				
Good; normal foliage			0	
Fair; thinning crowns			1	
Poor; very sparse foliage			2	
Very poor; some trees dead			3	_____

DAMAGE HAZARD INDEX - TOTAL